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Assessment of Ecosystem Services at Hathazari Upazila and Analyzing its Impacts on Human Wellbeing

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ABSTRACT

The overall objective of this research was to quantify provisioning services, assess regulatory services and investigate the cultural services provided by different ecosystem in Hathazari Upazila. The dominant land use type in Hathazari is Settlement with Vegetation which covered an area of 9949.59 ha (39.06%) comprising the homestead forest, 6921.45 ha (27.18%) of forest land, 4330.08 ha (17%) of Agricultural land, degraded forest 1762.56 ha (6.92%), Barren Land 1282.05 ha (5.03%)& Water body 1223.64 ha (4.80%). The study depicted that Hathazari Upazila has a growing stock of 2.19 million m^3 (316.87 m^3/ha) in plantation forest & 2.81 million m^3 (282.23 m^3/ha) in homestead forest. Quantitative structure reveals that *Acacia auriculiformis*&*Swietenia mahagoni* are dominant in plantation forest & homestead forest respectively. *Acacia auriculiformis* possess highest value for basal area per hectare (6.26 m^2/ha), IVI (82.92%), volume per hectare (64.71 m^3/ha) & density (216 stem/ha). On the other hand,*Swietenia mahagoni* possess highest value for basal area per hectare(5.88 m^2/ha), IVI (80.25%), volume per hectare (65.24 m^3/ha), density (169 Stem/ha) in homestead. The study regarding regulating services depicted that the total living biomass (779.50 ton/ha) & carbon stock (366.37 ton/ha) for plantation forest is greater than the total living biomass (694.28 ton/ha) & carbon stock (326.31 ton/ha) for homestead forest. An amount of about 93.075 ton of fuelwood is collected from this ecosystem per year. Gross expenditure value of recreation services may be valued more than Tk. 34.50 million per year & almost 82.72% of the visitors were agreed to pay willingly which will be Tk. 2.70 million annually. During the survey people's perception on ecosystem services was quite positive in improvement of the nearest forest &80.67% of them think homestead forests are increased over the time. From their perspective most vital ecosystem service obtained are food (72.69%) followed by wood, fiber, bio-fuels & plant oils (72.27%), oxygen (48.32%), climate & air quality (21.43%), carbon sequestration & storage (15.13%), aesthetic (9.24%), medicinal resources (7.56%), fresh water (5.46%), recreational (3.78%) and tourism (1.68%).

Keywords: Ecosystem, Plantation forest, Homestead forest, Provisioning services, Regulatory services, Cultural services.

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1. Introduction

Millions of species live on earth in different ecosystem depends on their nature. The vast majority gain energy to support their metabolism either directly from the sun, in the case of plants, or, in the case of animals and microbes, from other organisms through feeding on plants, predation, parasitism, or decomposition. In the pursuit of life and through their capacity to reproduce, organisms use energy, water, and nutrients. Terrestrial plants obtain water principally from soil, while animals get it mainly from free-standing water in the environment or from their food. Plants obtain most of their nutrients from the soil or water, while animals tend to derive their nutrients from other organisms. Microorganisms are the most versatile, obtaining nutrients from soil, water, their food, or other organisms. Organisms interact with one another in many ways, including competitive, predatory, parasitic, and facilitative ways, such as pollination, seed dispersal, and the provision of habitat. These fundamental linkages among organisms and their physical and biological environment constitute an interacting and ever-changing system that is known as an ecosystem. Humans are a component of these ecosystems. Indeed, in many regions they are the dominant organism. Whether dominant or not, however, humans depend on ecosystem properties and on the network of interactions among organisms and within and among ecosystems for sustenance, just like all other species. As organisms interact with each other and their physical environment, they produce, acquire, or decompose biomass and the carbon-based or organic compounds associated with it. They also move minerals from the water, sediment, and soil into and among organisms, and back again into the physical environment. Terrestrial plants also transport water from the soil into the atmosphere. In performing these functions, they provide materials to humans in the form of food, fiber, and building materials and they contribute to the regulation of soil, air, and water quality. These relationships sound simple in general outline, but they are in fact enormously complex, since each species has unique requirements for life and each species interacts with both the physical and the biological environment. Recent perturbations, driven principally by human activities, have added even greater complexity by changing,

to a large degree, the nature of those environments (MA, 2003).

Humankind benefits from a multitude of resources and processes that are supplied by ecosystems. Collectively, these benefits are known as ecosystem services and include products like clean drinking water and processes such as the decomposition of wastes. While scientists and environmentalists have discussed ecosystem services for decades, these services were popularized and their definitions formalized by the United Nations 2005 Millennium Ecosystem Assessment (MEA), a four-year study involving more than 1,300 scientists worldwide. This grouped ecosystem services into four broad categories: ***provisioning,*** such as the production of food and water; ***regulating,*** such as the control of climate and disease; ***supporting,*** such as nutrient cycles and crop pollination; and ***cultural,*** such as spiritual and recreational benefits (MA, 2005).

As human populations grow, so do the resource demands imposed on ecosystems and the impacts of our global footprint. Natural resources are not invulnerable and infinitely available. The environmental impacts of anthropogenic actions, which are processes or materials derived from human activities, are becoming more apparent – air and water quality are increasingly compromised, oceans are being overfished, pests and diseases are extending beyond their historical boundaries, and deforestation is exacerbating flooding downstream (Vitousek *et al.,* 1997). The WWF states in its Living Planet Reports that in the last 30 years a third of the natural world has been obliterated (WWF 2010). It has been reported that approximately 40-50% of Earth's ice-free land surface has been heavily transformed or degraded by anthropogenic activities, 66% of marine fisheries are either overexploited or at their limit, atmospheric CO_2 has increased more than 30% since the advent of industrialization (Vitousek *et al.,* 1997).

Society is increasingly becoming aware that ecosystem services are not only limited, but also that they are threatened by human activities. The need to better consider long-term ecosystem health and its role in enabling human habitation and economic activity is urgent. To help inform decision-makers, many ecosystem services are being assigned economic values, often based on the cost of replacement with anthropogenic alternatives. The ongoing challenge of prescribing economic value to nature, for example through biodiversity banking, is prompting trans-disciplinary shifts in how we recognize and manage the environment, social responsibility, business opportunities, and our future as a species(source: Wikipedia).

Over the past decade, Ecosystem services (ESS) have become central to discussions about the sustainable management of natural resources (Dearing *et al*., 2012). This is very important to identify and assess the ecosystem services and values for conservation of biodiversity, nature reserve and to retain sustainable ecosystem (De Groot *et al*., 2010). Different scientific assessment tools and guidelines are available which may be helpful to assess the impact of ecosystem on environment and human wellbeing (Maes*et al*., 2011). Ecosystem of HathazariUpazila is very complex comprising various naturalresources (e.g. classified forest, hilly areas, pasture land, rivers, streams etc.) and manmade resources (e.g. homestead, plantation, water bodies, canals, infrastructures, cultural sites) which apparently provides various ecosystem services including provisioning, regulating, cultural and other supporting services. All those services are widely contributing to environment through carbon sequestration, climate regulation, and pollution control &have positive impact on human wellbeing through different livelihood practices (e.g. agriculture, floriculture, horticulture, aquaculture, fishing, poultry, nursery, timber production, sawmill, cottage industry, NTFPs & fuelwood collection etc.) along with food, health, education, recreation etc.Considering the positive aspect sustainable management of the ecosystem is highly important. Accordingly we need to assess& manage almost all theecosystem services along with its impacts on human wellbeing.Although there are several studies on Chittagong University & adjacent areas but there is lack of comprehensive study on whole Hathazari Upazila especially on ecosystem services. In this backdrop this study has been conducted to understand& assess the prospects and constraints of the ecosystem serviceswhich may help to formulate actions for maintaining & restoring ecosystem functions through identification, assessment, quantification of ecosystem services towards ensuring human wellbeing.

The general objective of the study was to identification and assessment of available ecosystem services in the study area. However to fulfill the general objectives the specific objectives of this study were as follows:

- To identify and assess the ecosystem services(provisioning, regulating and cultural services) at HathazariUpazila.
- To evaluate diversity of plant species in both plantation & homestead forest.
- To evaluate the impacts of ecosystem on forest conservation and human wellbeing analyzing people's perception.
- To provide suggestions and recommendations for sustainable ecosystem services.

2. Materials and Methods

2.1 Materials

Several GIS and statistical software were used in the study for classify the land use type, data collection, compilation, analysis and mapping. List of used software include Arc GIS version 10 (GIS analysis and mapping), Google Earth (Geo-referencing, validation of data etc.), and Microsoft excel (Field data analysis).

Landsat 8 (OLI) imagery of 02 February 2017 (as February is the peak of cloud free season in Bangladesh) has been collected from USGS earth explorer. After collecting the imagery Band 2, Band 3, Band 4, and Band 5 have taken to stack. Then the stacked imagery was clipped according to the boundary of Hathazari upazila. Boundary file was collected from the Diva GIS web portal.

Clipped imagery was then corrected in ATCOR to reduce atmospheric and topographic errors. Several studies suggest the importance of pre-processing and atmospheric correction (i.e., data selection, radiometric calibration, haze reduction, and normalization) for an accurate and reliable land use classification (Scheidt, Ramsey and Lancaster, 2008; El Bastawesy, 2014).

Different types of instruments were used in the fields which include GPS (For tracking, ground truthing and taking geo-positions), Spiegel Relaskope (For tree height measurement), diameter tape (For diameter measurement), measuring tape (For plot and distance measurement), peg (For sample plot demarcation), and Ranging Rod (For height and depth measurement).

2.2 Indicators and Assessment of Ecosystem services

TEEB (2009) and Maes *et al*. (2011) discussed about several ecosystem services along with a number of indicator and parameter for assessment. In this study several indicators were used for assessment purpose. The ecosystem services and indicators that have been used in the study are illustrated in (Table 1).

Table 1: Provisioning, Regulating & Cultural Services and Indicators used for ecosystem assessment

Services type	Indicators
Provisioning (Raw materials)	• Forest growing stock • Forest biomass • Firewood
Regulating (Climate)	• Total amount of Carbon sequestered/stored
Cultural (Aesthetic information)	• Potential tourism site
Cultural (Recreation and ecotourism)	• Types of Recreation services and cultural values

2.3 Provisioning services assessment

2.3.1 Raw materials

First of all, satellite imagery was used to estimate the total vegetation cover area. LANDSAT imagery of the year 2018 are analyzed which were downloaded from the USGS Glovis website. That image for the study area was analyzed for changes in spectral patterns and these changes are classified into appropriate land cover categories. Image analysis and classification were carried out in Arc GIS. After classification area of each class was calculated. Details on satellite data acquisition are discussed in mapping methodology section.

Total 65 representative sample plots of size (20 m×20 m) from plantation forest and 20 sample plots of size (20 m×20 m) from homestead were taken through purposive random sampling at different unions of the study area. The number of selected sample plots was more in plantation than homestead, due to our giving emphasis on plantation for assessment of growing stock measurement & uniform nature of homestead. Figure 1 shows the distribution of sample plots for assessment of growing stock; this map was prepared in GIS platform using extracted data from GPS.

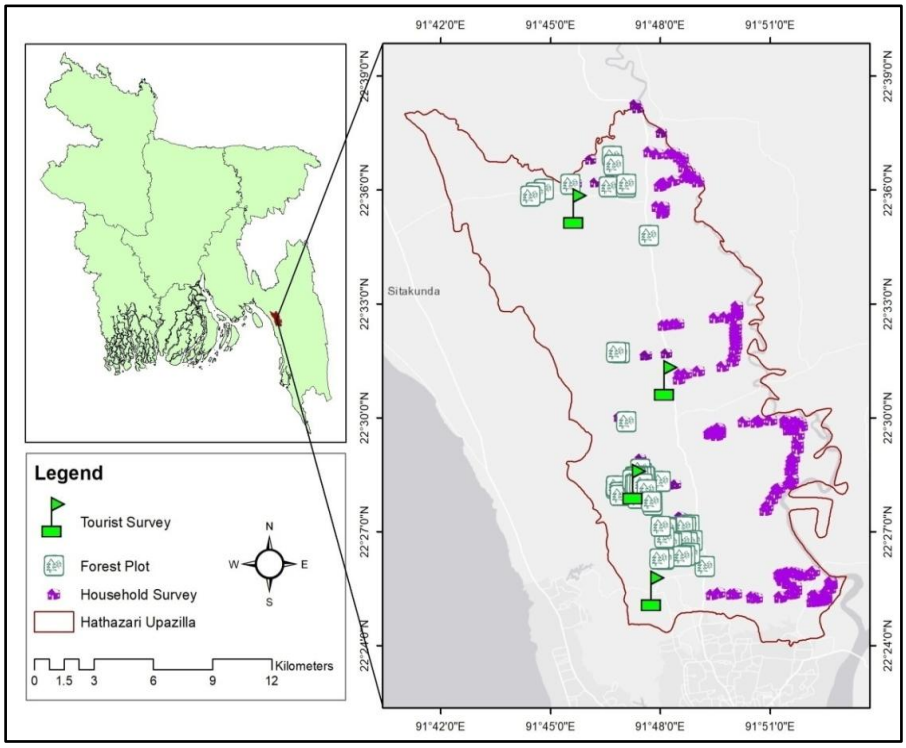


Figure 1: Map showsgraphical distribution of survey or sample plots in the study area

Total height (m) and DBH (cm) were measured using Spiegel Relaskope and diameter tape respectively. Plot size was determined by measuring tape and geo-position was determined using GPS. Data on diversified genetic resources, ornamental and medicinal plants diversity were also recorded during the data collection.

Collected data were processed and compiled in MS Excel. Analyzing the data (height and DBH) Basal area and volume of the trees were calculated. Then the volume was multiplied with the total vegetation cover area (from image classification) to estimate the total growing stock of the study area.

Following formula (Chaturvedi and Khanna, 1982) was used to calculate and estimate the basal area and volume of trees:

$$\textbf{Basal area } (m^2) = \pi D^2/4$$

$$\text{Where, D} = \text{ diameter at breast height and } \pi = 3.1416$$

$$\text{Volume } (m^3) = \text{ Basal area} \times \text{ Height}$$

$$\text{Where, D} = \text{ diameter at breast height, } \quad \text{Ht} = \text{ Total Height, } \quad \text{and } \pi = 3.1416$$

Using Moore and Chapman (1986), Shukla and Chandel (1980) and Dallmeier *et al.* (1992) formula the Density, Relative density (RD %), Frequency, Relative frequency (RF %), Relative dominance (RD_0 %), IVI (Importance value index) of each species were calculated.

1. Density of a species $= \frac{\text{Total no. of individual of a species in all quadrates}}{\text{Total no of quadrates studied}}$
2. Relative density of a species (RD) $= \frac{\text{Total no. of individual of a species in all quadrates}}{\text{Total no.of individual of all species}} \times 100$
3. Frequency of a species $= \frac{\text{Total no. of quadrates in which species occurs}}{\text{Total no. of quadrate s studied}} \times 100$
4. Relative frequency of a species (RF) $= \frac{\text{Frequecncy of one species}}{\text{Sum of all frerquencies}} \times 100$
5. Abundance of a species $= \frac{\text{Total no. of individual in all quadrates}}{\text{Total no. of quadrates in which species occurs}} \times 100$
6. Relative abundance of a species (RA) $= \frac{\text{Abundane of a species}}{\text{Total abundance of all the species}} \times 100$
7. Relative dominance of a species (RD_O) $= \frac{\text{Total basal area of a species in all quadrates}}{\text{Total basal area of all species in all quadrates}} \times 100$
8. IVI (Importance Value Index) $=$ RD % $+$ RF % $+$ RDo %

2.4 Regulating services assessment

Tree absorbs CO_2 from the atmosphere and stored organic carbon in its biomass. The biomass include both above and below ground biomass. Organic carbon stock of the trees was measured following the procedure of Global Forest Resource Assessment (GFRA) (FAO, 2010). First of all, above ground biomass and below ground biomass of the trees were calculated from the total growing stock of the trees more than 7cm in diameter. The total growing stock was multiplied by the biomass carbon expansion factor (BCEF) 2.05 for getting the above ground biomass and 20% of the above ground biomass was considered as the below ground biomass according to GFRA, 2010. A default value of 0.47 was used to convert the biomass value into carbon content.

- Above ground biomass = Growing stock (volume) × 2.05 (BCEF)
- Below ground biomass = above ground biomass × 0.20 [20% of AGB]
- Total biomass = above ground biomass + below ground biomass
- Organic Carbon content = biomass × 0.47 [0.47 = Default value]
- Total amount of carbon sequestered/stored = sequestration/storage capacity per hectare × total area (CO_2)

2.5 Cultural services

To measure the different parameters and indicator of Cultural services a well-defined semi structured survey was carried. Questionnaire survey was primarily carried out for 81 respondents in several location of the study area.Figure 1 shows the distribution & location of tourist spots for assessment of tourist survey; this map was prepared in GIS platform using extracted date from GPS. Respondent of the survey includes both outsider visitors and the local people living within the study area. Collected data was compiled and analyzed using MS excel to gather different information regarding cultural services. One map is produced to visualize different aspects of cultural services: potential ecotourism places and objects (based on the visitor's preferences) including diversified features categorized under different cultural services and values e.g. potential ecotourism sitesand willingness to pay etc. Visitor's willingness to pay for the recreation services was also estimated through questionnaire survey.

2.6 Socio economic survey

238 households from 15 unions were selected proportionately (based on population density %) & random sampling basis for socio-economic survey to assess people's perception on ecosystem services. Figure 1 shows the distribution of sample plots for assessment of socio-economic survey; this map was prepared in GIS platform using extracted date from GPS. The survey was conducted by interviewing the household members with semi-structured questionnaire based on observation and open discussion. The 238 households were selected from 15 unions which cover the whole upazila. The survey was done in urban, semi-urban

and rural places in the upazila. The survey was designed to gather information about the following issue: income source & income, forest resources & dependency, forest condition, social aspects depend on ecosystem services, solid waste management and perception on forest.

We used a Generalized Linear Model (GLM), popularly known as logistic regression model, to evaluate people's perception on the status of homestead forest condition in the Hathazari Upazila. GLMs are made up of three components: Random, Systematic, and Link Function. The random component identifies the dependent variable (Y = 0 or 1) and its probability distribution, the systematic component identifies the set of explanatory variables (Xi), and the link function identifies a linear relationship between the explanatory variables and their probability function.

We conducted extensive field survey which determined the explanatory variables those might have leverage on people's perception on status of homestead forest. From the survey, variables with overlapping information and multicollinearity issues were dropped off by checking the correlation matrix, where highest correlation of 0.30 was taken into consideration. To evaluate the factors which determines people's view, in the logistic regression, dependent variable was status of homestead forest in Hathazari Upazila (1 if homestead forest increasing, 0 otherwise); EDUCATION= Number of schooling years of the respondent; AREA_TYPE= Location of the household (1=Semi-urban, 0=Rural); HOSPITAL= Whether hospital available at 3km radios (1= Yes, 0=Otherwise); FUEL WOOD= Collect fuel wood from nearby forest (1=Yes, 0=Otherwise), BELIEF= Cultural belief related to forest (1=Yes, 0=Otherwise).

2.7 Mapping of ecosystem services

Ecosystem mapping can be done in two ways: Direct Mapping and Indirect Mapping. The observable and measurable features can be mapped directly from Aerial photos and Remote Sensing data, or indirectly from databases with ground data put in Geographical Information Systems. The term Direct Mapping involves the process of developing maps from remote sensing (RS) images and aerial photography (e.g. LANDSAT Data, ASTER and Google Earth Images etc.) and Indirect Mapping is the process of transforming (field) data into maps (Maes *et al.*, 2011).

Indirect mapping is mainly based on the collected and analyzed field data. It involves use of GPS device and collection of various field based primary and secondary data. GPS devices were used to fix the geo-position and tracking of various forest plots, household and tourist spot features. Primary data were collected in different ways (sampling, survey and personal observation). Secondary data were collected from various relevant authorities. Expert opinion was also considered. Both direct and indirect mapping can be done in several GIS software. But working with suitable and integrated software may be helpful for easy understanding and flexibility. Now a day, Arc GIS is widely used for GIS mapping. Before going for any GIS mapping and analysis a base map have to be created. Base map of Hathazari upazila was produced in Arc GIS.

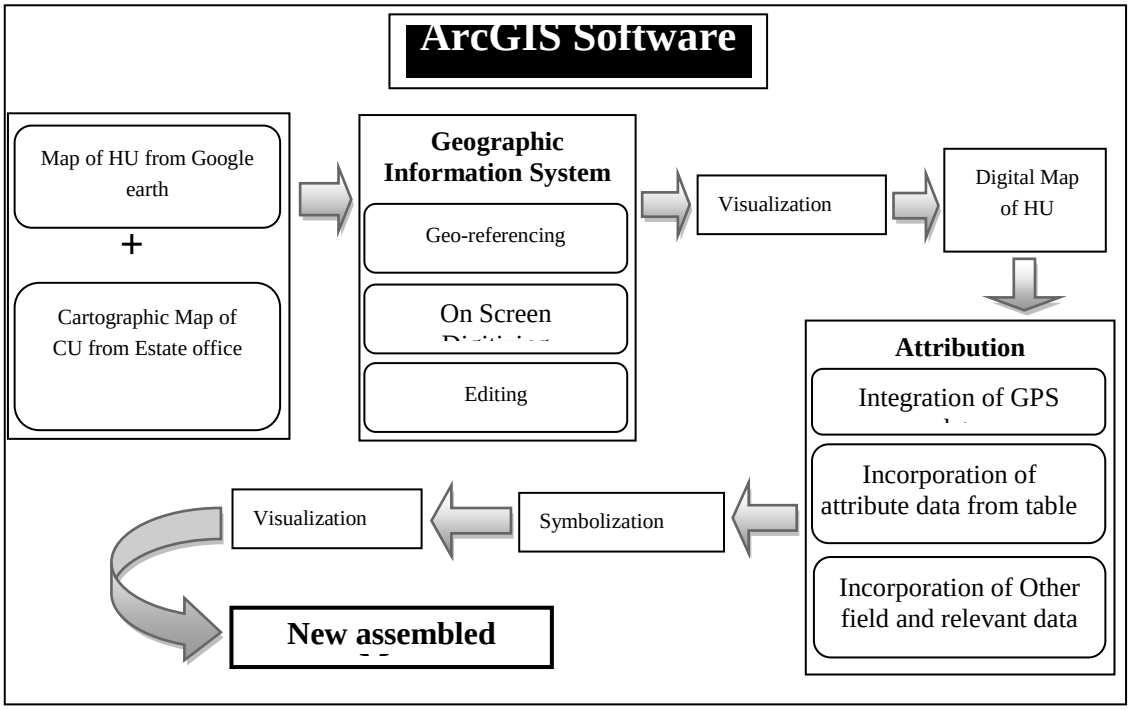


Figure 2: Workflow diagrams of mapping in Arc GIS

Before final mapping some other work has to be done including Integration of GPS data, creating shape files, attribution (attribute table preparation), generation of base map, satellite image stacking, sub-setting or clipping of AOI, image classification (analysis). Map projection and map preparation. Workflow diagrams of entire mapping operation are presented step by step in Figure 2.

3. Results and Discussion

3.1 Land use

The results and discussion chapter focuses on the three types of ecosystem services, categorizing as provisioning, regulating and cultural services at Hathazari upazila. The study primarily focused on identification and quantification of ecosystem services which are available in the study area. At first

total land area of Hathazari upazila is categorized by using GIS Map.

Satellite imageries have been analyzed through GIS platform for identification and assessment of existing major land use of the study area. Table 1 shows estimated area of different land use of the study area. The area has been calculated from satellite image analysis and calculating the digitized boundary using GIS software. Major land use type includes: Settlement with Vegetation (39.06%), Forest (27.18%), Agricultural Land (17%), Degraded Forest (6.92%), Barren Land (5.03%) & Water body (4.80%). The dominant land use type in Hathazari is Settlement with Vegetation which covered an area of 9949.59 ha comprising the homestead forest. The other land use types coverage are forest land is about 6921.45 ha, 4330.08 ha of Agricultural land, degraded forest 1762.56 ha, Barren Land 1282.05 ha & Water body 1223.64 ha. The Settlement with Vegetation land area is dominant because joint families are converted as a single family as a result they make new household in the agricultural and forest land. Deforestation is occurred due to logging, agricultural activities, urbanizations, forest fires and flood.

Table 1: Land use type of the study area

Land use type	**Area (ha)**	**Percentage**
Settlement with vegetation	9949.59	39.06
Forest	6921.45	27.18
Agricultural land	4330.08	17.00
Degraded Forest	1762.56	6.92
Barren land	1282.05	5.03
Water body	1223.64	4.80
Total	**25469.37**	**100.00**

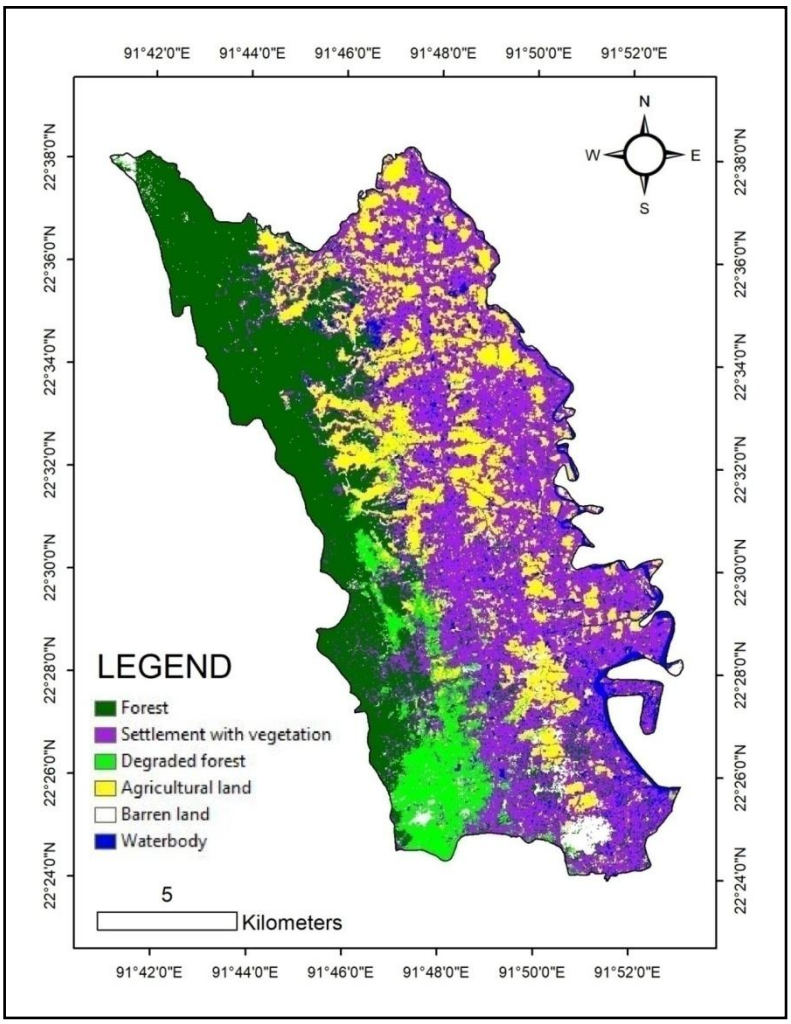


Figure 1: Map showing the existing land use type in Hathazari Upazila

Forest land has also seen as a degraded forest and barren land due to new household, brickfield making, new agricultural land forming and encroachment. Because of brickfield making forest & agricultural land is extremely affected. From hilly area, plain & agricultural lands are cutting for soil which is converted into brick. For making brick huge firewood is used which come from forest by illicit felling.It covers a large area and is responsible for air pollution, crop loss, decreased soil fertility and subsequent reductions in crop production. Due to forest degradation as well as reduces of forest resources people recently depends on homestead forest. In addition to forest ecosystems, the homestead forest ecosystem has given priority to this study. However, overall land use pattern of the study area is favorable to support various ecosystem services.Distributions of different land use in the study area are shown graphically in Figure 1.

3.2 Provisioning services

Three types of provisioning services of Hathazari upazila were quantified in this study. These are forest growing stock, firewood, forest biomass, genetic resources and food. Under genetic resources, four separate types of resources were discussed.Under each service there are indicators which will reflect the pertaining services to its goal.

3.2.1 Forest growing stock

Growing stock and basal area

From the analysis of 65 sample plot data from plantation forest estimated amount of total growing stock is about 2.19 million m^3 in total area of 6921.45 ha. Estimated volume per hectare is about 316.87 m^3. Estimated amount of total basal area in study area is about 0.178 million m^2 at 25.75 m^2 per hectare (Table 2).

Table 2: Estimated amount of growing stock and basal area

Forest type	**Estimated Growing stock/Volume**		**Basal Area**	
	Per hectare (m^3/ha)	In total area (m^3)	Per hectare (m^2/ha)	In total area (m^2)
Plantation Forest	316.87	2,193,199.86	25.75	178,227.34
Homestead Forest	282.23	2,808,072.79	22.86	227,447.63

In a comparative study shows that from the analysis of 36 sample plot data estimated amount of total growing stock was about 103619.70 m^3 (using the vegetation area estimate of 2012). Estimated volume per hectare was about 673.25 m^3. Estimated amount of total basal area was about 6877.4 m^2 and per hectare basal area 44.68 m^2(Sayeam and Amin, 2013)was reportedat plantation forest in Chittagong University Campus. Both growing stock and basal area of CU campus are almost double to above findings result of Hathazari upazila. It's happening because CU campus plantation forest is so rich with volume and dense. Because CU campus forest is scientifically managed by IFESCU and CU authority. But for HU plantation forest's total growing stock and basal area is higher than theCU campus due to covering more plantation area.

From the analysis of 20 sample plot data from homestead forest estimated amount of total growing stock was about 2.81 million m^3 in total area of 9949.59 ha. Estimated volume per hectare was about 282.23 m^3. Estimated amount of total basal area in study area wasabout 0.227 million m^2 at 22.86 m^2 per hectare (Table 2).

From the above study we found slight difference in growing stock per hectare where plantation forests possess the better growing stock & basal area than the homestead forest. This might be due to lower density, species types & uneven height & DBHof the homestead forest species. However total homestead forest area (9949.59 ha) has more volume as it covers more area than the plantation forest (6921.45 ha) of the study area.

Higher growing stock & basal area in the study area represent the healthy, rich and sustained ecosystem. The study result depicts that entire ecosystem of the study area is holding considerable amount of growing stock for timber & biomass production which is also contributing in providing other ecosystem services.However, the growing stock of the study area can be increased in greater extend through intensive plantation activities with suitable species and taking proper management strategy.

3.2.2Quantitative structure of Vegetation in Plantation and Homestead forest

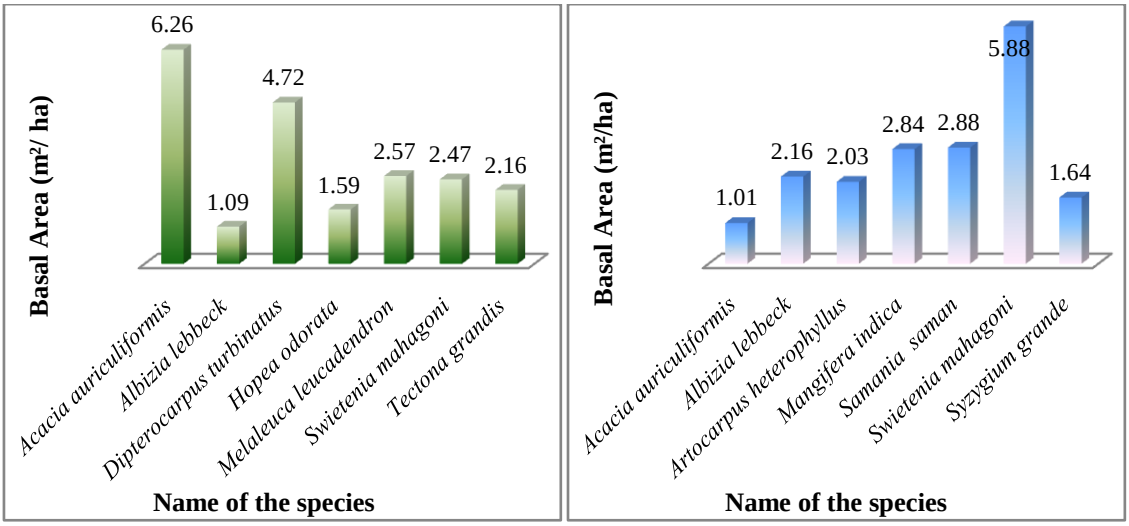
The quantitative structure of the vegetation was studied based on the density; basal area, relative density, frequency, abundance, relative abundance, dominance,

relative dominance and Importance Value Index (IVI) are described in the following sections.

Basal Area (BA)

Basal Area (BA) per hectare of seven dominant tree species in plantation forest was graphically shown in Figure 2 A. The maximum basal area was recorded for *Acacia auriculiformis* (6.26 m^2/ha), followed by *Dipterocarpus turbinatus* (4.72 m^2/ha), *Melaleuca leucadendron*(2.57 m^2/ha), *Swietenia mahagoni* (2.47 m^2/ha), *Tectona grandis* (2.16 m^2/ha), *Hopea odorata* (1.59 m^2/ha) and *Albizia lebbeck* (1.09 m^2/ha).

Basal Area (BA) per hectare of seven dominant tree species in homestead forest shown in Figure 2 B. The maximum basal area was recorded for *Swietenia mahagoni* (5.88 m^2/ha) followed by *Samania saman* (2.88 m^2/ha), *Mangifera indica* (2.84m^2/ha), *Albizia lebbeck* (2.16 m^2/ha),*Artocarpus heterophyllus* (2.03 m^2/ha), *Syzygium grande* (1.64 m^2/ha) and *Acacia auriculiformis* (1.01 m^2/ha).



A **B**

Figure 2: Basal area (m^2/ha) of seven dominant tree species **A.** Plantation forest &**B.** Homestead forest

Importance value index (IVI)

Maximum Importance value index (IVI) of major seven species was recorded for *Acacia auriculiformis* (82.92%) followed by *Dipterocarpus turbinatus* (50.52%), *Swietenia mahagoni* (28.71%), *Tectonagrandis* (21.68%), *Melaleucaleucadendron* (20.32%), *Hopea odorata* (19.55%) and *Lagerstroemia speciosa* (12.82%) (Figure 3 A). It reveals *Acacia auriculiformis*is the highly chosen species for plantation forestry due to its fast growing, high yielding, adaptive nature, erosion controland meet the demand of fuelwood as well. Its wood is good for making paper, cost effective furniture and tools. It also a soil improver, plantations of *A. auriculiformis* improve soil physio-chemical properties such as water-holding capacity, organic carbon, nitrogen and potassium through litter fall. Its phyllodes provide good, long-lasting mulch. Furthermore it used for nitrogen fixing (Wikipedia). Besides this other timber species *Dipterocarpus turbinatus*(Garjan),*Swietenia mahagoni* (Mahagoni), *Tectona grandis*(Segun) are mainly planted for their greater economic & superior timber value. Overall *Acacia auriculiformis*& other identified speciesrepresent the core objective of plantation forestry in the study area which helps in rapid restoration of denuded or degraded ecosystem and maintains sustainable ecosystem services towards human wellbeing.

In a similar study reported that the highest IVI was recorded for *Acacia auriculiformis* (41.04 %) for plantation forest in Chittagong University campus (Barua and Alam, 2013). Furthermore a similar study (Islam and Amin, 2013) reported that *Acacia auriculiformis*had the highest importance value index (IVI) (20.73%) in Sitakunda Botanical Garden and Ecopark (SBGE).

The maximum Importance value index (IVI) was found for *Acacia auriculiformis*. From overall discussion it was clear that *Acacia auriculiformis*, *Dipterocarpus turbinatus* and *Swietenia mahagoni* were more dominant plantation forest tree species in Hathazari upazila.

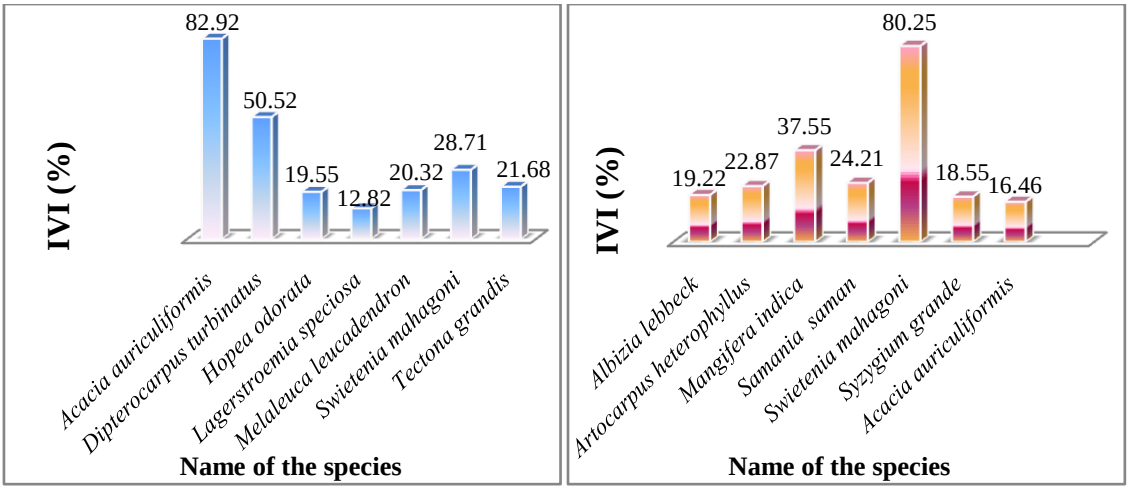


Figure 3: Importance value index (IVI) of seven dominant tree species **A.** Plantation forest &**B.** Homestead forest.

Importance value index (IVI) of major seven species was recorded for *Swietenia mahagoni* (80.25%) followed by *Mangifera indica* (37.55%), *Samania saman* (24.21%), *Artocarpus heterophyllus*(22.87%), *Albizia lebbeck* (19.22%), *Syzygium grande* (18.55%) and *Acacia auriculiformis* (16.46%) in homestead forest were shown in Figure 3 B.

In a comparative study shows that the highest IVI was recorded for *Switenia mahagoni* (43.00) in Chittagong University campus which is a combination of homestead and plantation forest (Sayeam and Amin, 2013).

The maximum Importance value index (IVI) was found for *Swietenia mahagoni*. From overall discussion it was clear that *Swietenia mahagoni*, *Mangifera indica* and *Samania saman* were more dominant homestead forest tree species accordingly timber, fruit and fuel wood species which are essential for livelihood in Hathazari upazila. However,*S. mahagoni* has been planted as the most dominant timber species in the homestead due to higher site suitability. It is a commercially important lumber prized for its beauty, durability, and color, and used for paneling and to make furniture, boats, musical instruments and other items. Due to lacking of teak timber, mahagoni is most preferable among people for furniture makingand other uses.Besides durability, its timber price is high in market.So, in the homestead forest as well as in plantation forest mahagoni species plantation is increasing day by day.

Density and Volume productivity

It's a measurement of density of individual stems and production per hectare in plantation and homestead forest.

Stem per hectare

The present study recorded a total of 650 stems/ha in 2.6 ha sampled area from plantation forest in Hathazari upazila. The density of individual stems was dominated *Acacia auriculiformis* (216) followed by *Dipterocarpus turbinatus* (106), *Swietenia mahagoni* (58), *Hopea odorata* (40), *Lagerstroemia speciosa* (40), *Tectona grandis* (39)and *Melaleuca leucadendron* (34) (Table 3).

Table 3: Growing stock of plantation forest tree species in Hathazari Upazila

Sl.	Species	Scientific Name	No.	Stem/ha	Volume (m^3)	Volume (m^3/ha)
1	Akashmoni	*Acacia auriculiformis*	562	216	168.25	64.71
2	Asbatta	*Ficus religiosa*	12	5	29.81	11.47
3	Bot	*Ficus bengalensis*	2	1	9.23	3.55
4	Champa	*Michelia champaca*	5	2	2.15	0.83
5	Chapalish	*Artocarpus chaplasha*	24	9	11.07	4.26
6	Chikrashi	*Chickrashia tabularis*	21	8	7.24	2.78
7	Gamar	*Gmelina arborea*	69	26	19.47	7.49
8	Garjan	*Dipterocarpus turbinatus*	275	106	148.96	57.29
9	Jarul	*Lagerstroemia speciosa*	103	40	15.72	6.04
10	Jhau	*Casuarina equisetifolia*	41	16	25.03	9.63
11	Kalo koroi	*Albizia lebbeck*	49	19	44.93	17.28
12	Mahagoni	*Swietenia mahagoni*	152	58	86.45	33.25
13	Mangium	*Acacia mangium*	65	25	25.99	10.00

14	Melaluka	*Melaleuca leucadendron*	89	34	101.00	38.84
15	Raintree	*Samania saman*	10	4	10.71	4.12
16	Sal	*Shorea robusta*	5	2	1.98	0.76
17	Segun	*Tectona grandis*	102	39	69.53	26.74
18	Telsur	*Hopea odorata*	104	40	46.35	17.83
		Total	**1690**	**650**	**823.86**	**316.87**

The study revealed that recorded a total of 496 stems/ha in 0.8 ha sampled area from homestead forest in Hathazari upazila. The density of individual stems was dominated *Swietenia mahagoni* (169) followed by *Mangifera indica* (50), *Areca catechu* (37), *Acacia auriculiformis* (32), *Artocarpus heterophyllus*(29), *Samania saman* (24) and *Tectona grandis* (24) in homestead forest (Table 4).

Table 4: Growing stock of homestead forest tree species in Hathazari Upazila

Sl.	Species	Scientific Name	No.	Stem/ha	Volume (m^3)	Volume(m^3/ha)
1	Akashmoni	*Acacia auriculiformis*	26	32	7.72	9.66
2	Am	*Mangifera indica*	40	50	22.43	28.03
3	Borta	*Artocarpus lakoocha*	2	3	1.46	1.83
4	Chapalish	*Artocarpus chaplasha*	2	3	1.65	2.06
5	Coconut	*Cocos nucifera*	14	17	11.85	14.82
6	Gamar	*Gmelina arborea*	7	9	0.65	0.81
7	Garjan	*Dipterocarpus turbinatus*	9	11	6.19	7.73
8	Guava	*Psidium guajava*	11	14	0.86	1.08
9	Jam	*Syzygium grande*	18	22	16.75	20.93
10	Jambura	*Citrus grandis*	5	6	0.61	0.76
11	Jhau	*Casuarina equisetifolia*	11	14	9.97	12.46
12	Kanthal	*Artocarpus heterophyllus*	23	29	17.13	21.42
13	Kalo koroi	*Albizia lebbeck*	17	21	27.49	34.37
14	Mahagoni	*Swietenia mahagoni*	135	169	52.19	65.24
15	Mohua	*Madhuca indica*	5	6	3.61	4.51
16	Neem	*Azadirachta indica*	4	5	0.33	0.41
17	Raintree	*Samania saman*	19	24	37.74	47.17
18	Segun	*Tectona grandis*	19	24	4.98	6.23
19	Supari	*Areca catechu*	30	37	2.17	2.71
		Total	**397**	**496**	**225.78**	**282.23**

Comparative analysis of the above result revealed that plantation forests are denser than the homestead forests. Due to presence of settlement, other livelihood & secondary land use practices tree species are mostly scattered & less dense in distribution. However most of the homestead tree species are greater in volume & height due to longer rotation compared to short rotation plantation forest.

Volume per Hectare (m^3/ha)

In Hathazari upazila the highest volume per hectare was found for *Acacia auriculiformis* (64.71 m^3/ha) followed by *Dipterocarpus turbinatus* (57.29 m^3/ha),*Melaleuca leucadendron* (38.84 m^3/ha), *Swietenia mahagoni* (33.25 m^3/ha), *Tectona grandis* (26.72 m^3/ha), *Hopea odorata* (17.83 m^3/ha) and *Albizia lebbeck* (17.28m^3/ha) (Table 3). *Acacia auriculiformis*volume was maximum due to more height andDBH.

In Hathazari upazila the highest volume per hectare was found for *Swietenia mahagoni* (65.24 m^3/ha) followed by *Samania saman* (47.17 m^3/ha), *Albizia lebbeck* (34.37m^3/ha), *Mangifera indica* (28.03 m^3/ha), *Artocarpus heterophyllus*(21.42 m^3/ha), *Syzygium grande* (20.93 m^3/ha), and *Cocos nucifera* (14.82 m^3/ha) (Table 4) in homestead forest. *Swietenia mahagoni* volume was maximum due to more height and DBH.

3.2.3 Biomass of Plantation Forest & Homestead Forest

Following the (FAO, 2010), a methodology for biomass estimation of growing stock, estimated value of total biomass of existing growing stock is about 5.40 million tons where above ground and below ground biomass is 4.50 million tons and 0.90 million tons respectively. Total biomass production is about 779.50 t/ha while above ground and below ground biomass is about 649.59 t/ha and 129.92 t/ha respectively (Table 5).

Table 5: Amount of biomass in growing stock of plantation forest in study area

Biomass Stock	Biomass (t/ha)	Total biomass in forested area (t)	Total Biomass (Million tons)
Above ground Biomass	649.59	4,496,073.62	4.50
Below Ground Biomass	129.92	899,214.72	0.90
Total Biomass	779.50	5,395,288.35	5.40

In a comparative study shows that total biomass production per hectare is about 828.10 t/ha while above ground and below ground biomass is about 690.08 t/ha and 138.02 t/ha (Sayeam and Amin, 2013) respectively at plantation forest in Chittagong University Campus which is nearest to above findings result of Hathazari upazila.

The study revealed that for biomass estimation of growing stock in homestead forest, estimated value of total biomass of existing growing stock is about 6.91 million tons where Above ground and below ground biomass is 5.76 million tons and 1.15 million tons respectively. Total biomass production is about 694.28 t/ha while above ground and below ground biomass is about 578.57t/ha and 115.71 t/ha respectively (Table 6).

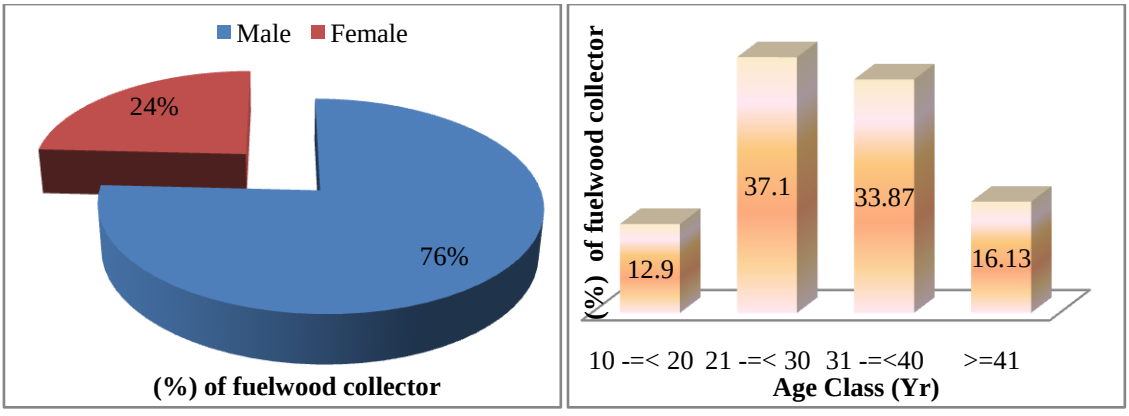
Table 6: Amount of biomass in growing stock of homestead forest in study area

Biomass Stock	Biomass (t/ha)	Total biomass in forested area (t)	Total Biomass (Million tons)
Above ground Biomass	578.57	5,756,540.61	5.76
Below Ground Biomass	115.71	1,151,308.12	1.15
Total Biomass	694.28	6,907,848.73	6.91

Study revealed that biomass content of plantation forest (779.50 t/ha) is comparatively higher than homestead forest (694.28 t/ha). Owing to plantation forest tree species density is more than the overall homestead forest species density. Actually plantation forest is uniform and maintain a certain distance, on the other hand homestead forest is not uniform and don't maintain a certain distance. But total biomass in homestead forest (6.91million tons) is comparatively greater than the plantation forest (5.40 million tons) because homestead forest comprises larger area than the plantation forest in the entire study area.

3.2.4 Total amount of firewood collected from Plantation forest

About 62 (26.05%) out of 238 surveyed people enter into nearest plantation forest for fuelwood/firewood collection according to the field survey. Most of the persons are male (76%) (Figure 4 A) and aged more than 20 years (37.1%) and more than 30 years (33.87%) (Figure 4 B). Most of the persons enter into the plantation forest for two times (48.39%) and for one time (37.09%) in a week (Figure 4 C). An amount of about 93.075 ton (approximately) of fuelwood is collected from this ecosystem per year (Table 7).



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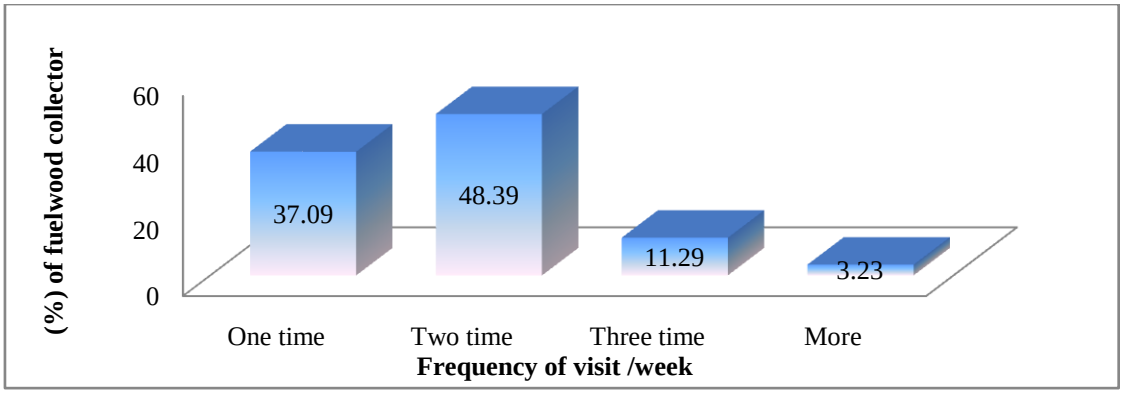

C

Figure 4:A. Percentage of respondent's **B.** Age class distribution **C.** Frequency of collection per week

Table 7: Amount of fuelwood collected per year

Average firewood/Person	No. offuelwood Collector/Day	Total No. of Collector/Year	Total amount (Kg)	Total amount (Ton)
17 kg	15	5475	93075	93.075

In a comparative study shows that 8 (eight) people enter into the Sitakunda Botanical Garden and Eco-park (SBGE) per day for firewood collection according to the field survey. Most of the persons are male and aged more than 30 years. Most of the persons used to enter into the forest for one time per week & approximately 43.2 ton of firewood was being collected from that ecosystem per year (Islam and Amin, 2013). Actually people's dependency is increasing day by day on both homestead forest, natural or plantation forest for firewood due to excessive use of firewood in brickfield, cooking purposes, local tea stalls & food shops. Mainly poor people residing in remote hilly areas are fully dependent on forest for fuelwood. But excessivedependency on fuelwood can be reduced by using of gas facility (cylindered LPG & gas pipeline) & introduction of modern cooking system.

3.3 Climate change regulation (Regulating Service)

3.3.1 Carbon sequestration

Carbon sequestration refers to the long-term storage of carbon in trees and plants which helps to reduce or slow down the buildup of CO_2 concentrations in the atmosphere. Sequestered carbon stored in growing plants in the form of biomass (EPA, 2012). Result showed that the total organic carbon stock in plantation forest of study area is about 2.54 million tons where total carbon stock per hectare area is about 366.37 t/ha (Table 8).

Table 8: Amount of carbon sequestration in plantation forest area of the study area

Area (ha)	Carbon Stock	Above Ground	Below Ground	Total
6,921.45	t/ha	305.31	61.06	366.37
	Total in Existing Growing Stock (Ton)	2,113,154.60	422,630.92	2,535,785.52
	Million Ton	**2.11**	**0.42**	**2.54**

In the comparative study result showed that the total organic carbon stock in forest or plantation of study area is about 0.12 million tons where total carbon stock per hectare area is about 778.41 t/ha (Sayeam and Amin, 2013). In this result per hectare carbon stock is more than double (778.41 t/ha) from above findings result (366.37 t/ha) in the study area of HU. Because Chittagong University campus is a dense forest than the overall plantation forest area of HU. As a consequence of density of trees carbon stock is more than double. But total carbon stock of CU Campus is too less (0.12 million tons) than HU (2.54 million tons) compare with total plantation forest area. In HU total area of plantation forest is comparatively too much from CU Campus plantation forest.

Table 9: Amount of carbon sequestration in homestead forest area of the study area

Area (ha)	Carbon Stock	Above Ground	Below Ground	Total
9,949.59	t/ha	271.93	54.39	326.31
	Total in Existing Growing Stock (Ton)	2,705,574.09	541,114.82	3,246,688.90
	Million Ton	**2.71**	**0.54**	**3.25**

Another result showed that the total organic carbon stock in homestead forest of study area is about 3.25 million tons where total carbon stock per hectare area is about 326.31t/ha (Table 9).

Above both study, carbon stock of plantation forest (366.37 t/ha) is more than the homestead forest (326.31t/ha). Owing to plantation forest tree species density is more than the overall homestead forest species density. Actually plantation forest is uniform and maintain a certain distance and proper scientific management otherwise homestead forest is not uniform and don't maintain a certain distance and management. But total carbon stock is more in homestead forest (3.25 million tons) than the plantation forest (2.54 million tons) comparatively because of homestead forest area is more than the plantation forest area. Now a days people are highly interested and conscious about homestead forest to fulfill their demand for timber, foods, fuelwood and others resources. In this perspective the study area is providing moderate growing stock to sequester carbon which might be increased through enrichment planting in barren land & hilly areas.

3.4 Tourism Potentiality (Cultural services)

Based on the field survey and discussion with concerned authority in different sites, it was found that people are coming from distance places to visit the several sites throughout the year which indicates that, the study area possess significant & diversified tourism potentialities. The numbers of tourists visiting the area are greater during the winter season than the other season. So for the scientific management of this Upazila's identified sites as an eco-tourist site, the carrying capacity of the Upazila needs to be determined.

3.4.1 Important tourist places in Hathazari upazila

Table 10: Recreational facilities available in Hathazari upazila

Place	Attractive icon
Chittagong University Campus	**IFESCU campus** (Lake, Director Building, Helipad, dense forest, Nursery, Bamboo Bridge, Watershed, Lily pond, NTFP Plantation, Masterda surja sen statue), **Botanical garden (**Flower garden, ornamental garden, cactus house, Fish Project, Plantation, stream, pond, Orchidarium and Conservatory house), **Central Campus** Historical places (Shahid Minar, Buddhijibi chattar, Shadinotha Smarok Vaskorjo, VC Resident & Hilly Area, Kathapahar, CU Museum, Library and Research center for mathematical and physical sciences), **Social Science (**Tsunami Garden, Suspension bridge, Teletalk tower, Infrastructure), **Arts faculty** (Stream, Jhupri), **North Campus** (Bissho Shanthi Pagoda and Sluice Gate), **Central field (**Green grasses, Sport activities) and **Whole campus (**1No. road, all roadside, halls, institutions are decorated with ornamental tree species, Gol Pukur Area, playground and infrastructure**)** etc.
Udalia Tea State	Tea garden and Natural beauty.
Hathazari Agricultural Institute	Horticulture center , Institute, Flower garden etc.
Café 24	Lake, Boating, Foot trail, Nursery, Restaurant etc.

Table 10 shows all important tourist places in Hathazari upazila. Actually four major spots are identified above in which all spots are notable and a proposed eco-park with botanical garden are described below.

Proposed Eco-park and botanical garden at Mondakini in Hathazari Upazila

The eco-park and botanical garden will be built in Mondakini Forest Beat area of Hathazari range. Initially, infrastructure and offices will be set up while other facilities will be developed gradually.

3.5 Valuation of recreation services

In general, the study area is not regarded as the ecotourism site and no one used to pay for the recreation services. But it provides some recreation facilities which may be eligible for payment services. Café 24 has some recreational, refreshment & ecotourism facilities. For this reason people's response to payment services were evaluated. To do that a questionnaire survey was conducted at different location of the study area. A total of 81 visitors were surveyed to get information on their gross expenditure to visit the study area. Moreover, their response to willingness to pay for recreation services was also considered.

Result showed that most of the visitors (almost 82.72%) were agreed to pay for the recreation services. In café 24, visitor's already pay Tk. 50 for every adult access. Taking Gross expenditure value of recreation services may be valued more than Tk.34.50 million per year. On the other hand, through payment

(Willingness to pay) estimated value of recreation services may be more than Tk. 2.70 million per year. Willingness to pay' ranges from Tk. 10-50 and on an average Tk.18.77 per individual. However, improved facilities may raise the willingness to pay value (Table 11).

Table 11: Gross expenditure method and willingness to pay (Amount in Taka)

Respondent		Travel Cost	Entry Fee (Willingness to pay)	Others (Food, Ride, Boat etc.)	Gross Expenditure
Total=81		10995	1520	6890	19405
Average		135.74	18.77	85.06	239.57
Daily	**400**	54296.30	7506.17	34024.69	95827.16
Monthly	12000	1628888.89	225185.19	1020740.74	2874814.81
Annual	144000	19546666.67	2702222.22	12248888.89	34497777.78

In a comparative study result showed that most of the visitors (almost 78%) were agreed to pay for the recreation services. Willingness to pay' ranges from 10-40 Tk. and on an average 14.55 Tk. per individual (Sayeam and Amin, 2013) which is almost similar to the above finding.

3.6 Demographic aspects of the respondents

The study describes the socio-economic condition of the native peoples and total 238 households were surveyed to assess the socio-economic condition of the respondents in the study area. Demographic information's are given below:

3.6.1 Present household income & income sources

In monthly income greater portion come from Agriculture activities (29.18%) and business (22.99%), then Service (14.64%), Transport & Communication (8.47%), Remittance (7.55%), Fishing (5.08%), Non-agricultural laborer (3.76%), Forest (2.79%) and livestock (1.62%) are considerable. Total percentage of Income from all forestry related activities is about (4.24%). Monthly Income from Agriculture varies from min Tk.900 to Tk.20000/-, Business income varies from Tk.2000/- to Tk.40000/-, Service income varies from Tk.10000/- to Tk.28000/-, Transport & Communication income varies from Tk.6000/- to Tk.150000/-, Remittance income varies from Tk.10000/- to Tk.30000/-, Fishing income varies from Tk.2000/- to Tk.12000/-, Non-agricultural laborer income varies from Tk.4000/- to Tk.12000/-, From livestock's income varies from Tk.800/- to Tk.12000/-. Monthly Income from forest activities where included (Forest, Homestead forest, Fruit garden, Cottage industry and Agro forestry) can be average more than Tk.5000/-which indicates people dependency on homestead forest & forest products (Figure 5).

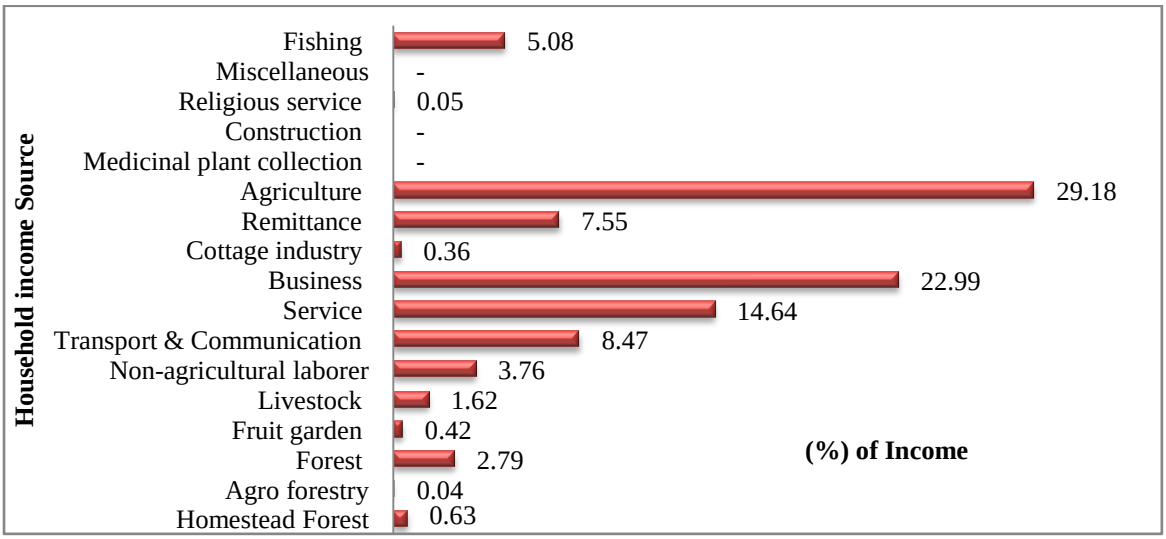

Figure 5: Present household income & income sources

3.7 People's perception on Ecosystem Services

This part of the study describes the people's perception based on their knowledge and perception regarding different aspects of ecosystem services. In this connection total 238 households were surveyed on random sampling basis via a well-defined questionnaire. The findings from the survey are depicted below:

3.7.1 Forest resources and dependency of the villagers

Forest resources represent the provisioning services and people's proper dependency is a positive sign for a sustainable ecosystem. Considering the livelihood dependency level on Hathazari upazila the study revealed that among 238 HHs only 86 Households (36.13%) are depends on some forest products such as fuel wood (26.05%), Fallen Leaves/Litter (8.40%) and bamboo (1.68%). The household involves in fuel wood collection earn Tk.1214.84 on average per month, where Bamboo collector earn Tk. 3150/- on average from sale of the collected products (Figure 6).

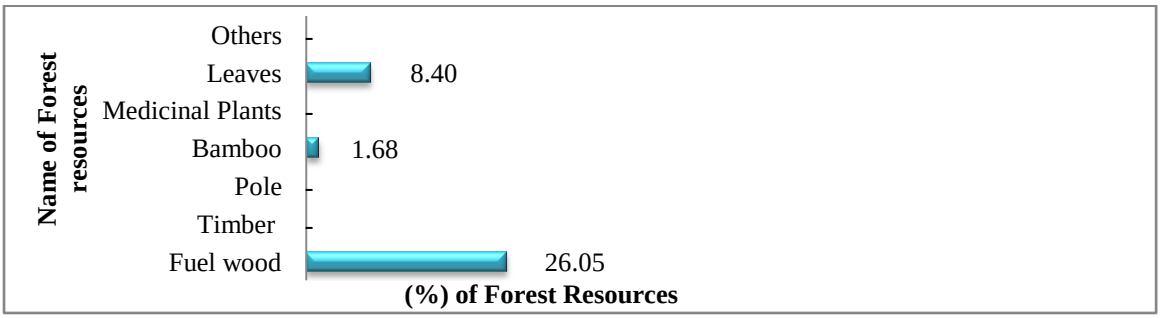

Figure 6: Percentage of HH uses of forest resources

3.7.2 Conditions of the nearest forest

Considering the survey respondents gave their opinion about conditions of nearest forest that improving (46%) followed by deteriorating (43%) and no changed (11%) (Figure 7). Maximum respondents said nearest forest are improving as a consequence of less dependency on forest.

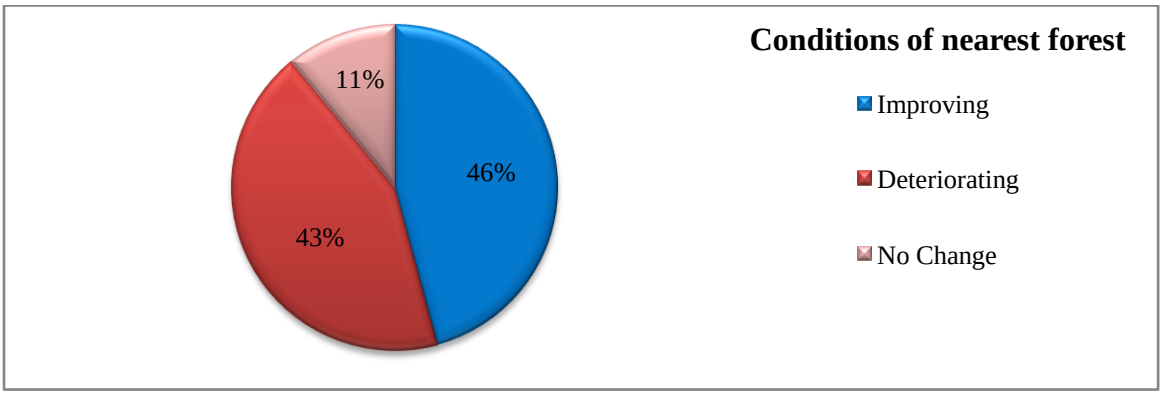

Figure 7: Conditions of nearest forest

But many respondents in addition said, forest is deteriorating caused by massive dependency on forest for firewood. Firewood includes cutting trees of sapling stage, collection of twigs and litter that eventually decreases the humus or soil nutrient content which create obstacle for development of healthy forest ecosystem alongwith disturbance for the wildlife also. In this context, forest of the study area must be managed sustainably by restricting fuelwood collection.

3.7.3 Social aspects depend on ecosystem services

Described indicators represent the provisioning, regulating, cultural and supporting ecosystem services as well as whole ecosystem services. People's perception is clarified behind using those services. Respondentsexpressed their social aspects based on ecosystem services. The local communities are getting different types of ecosystem services from the forest and agricultural ecosystem available in the study area. The people are directly or indirectly depend on those services. According to the respondents, the most important ecosystem service they enjoyed are food (72.69%) followed by Wood, Fiber, biofuels & plant oils (72.27%), Oxygen (48.32%), Climate & air quality (21.43%), Carbon sequestration & storage (15.13%), Aesthetic (9.24%), Medicinal resources (7.56%), Fresh water (5.46%), Recreational (3.78%) and tourism (1.68%) (Figure 8).

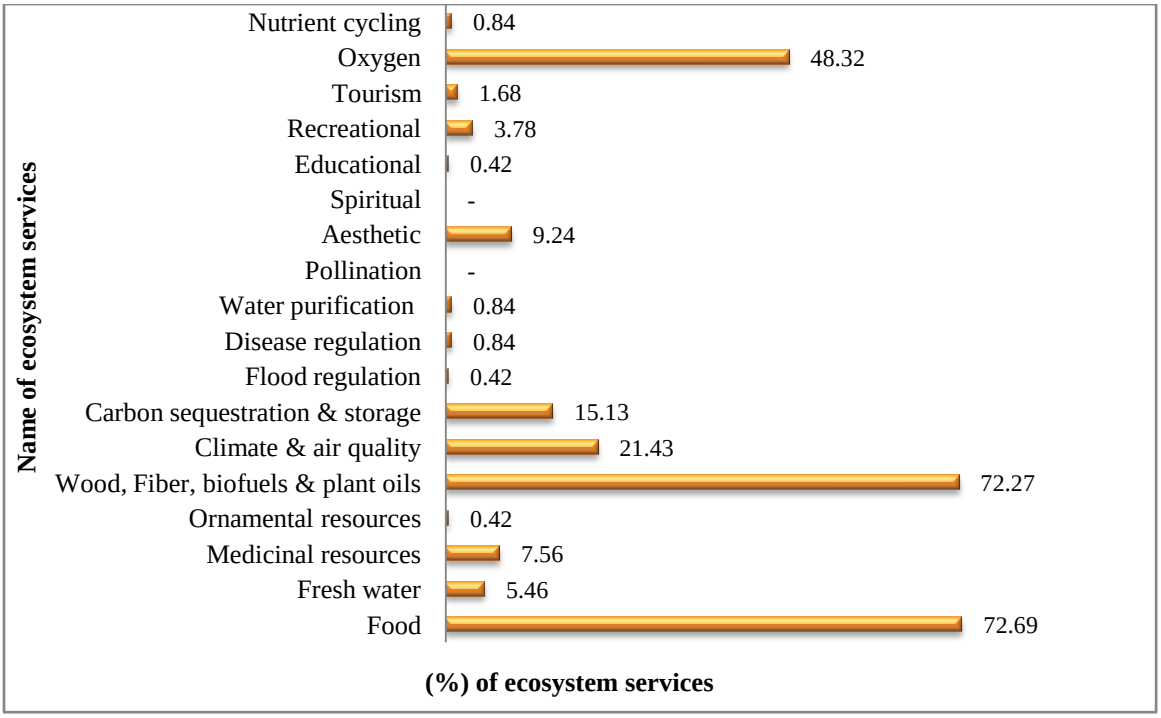

Figure 8: Social aspects depends on ecosystem services

Worldwide,795 million people go hungry every day. With the world population projected to exceed nine billion people by 2050, global agricultural output must expand by an estimated 60 percent to meet global food needs. Yet, in many places, deforestation triggered by escalating demand for food, wood, fiber and bio-fuel is degrading ecosystems, diminishing water availability and limiting the collection of fuel wood all of which reduce food security, especially for the poor. Natural forests are critical for the survival of forest-dwellers, including many indigenous peoples, and they help deliver clean water to agricultural lands by protecting catchments. Farmers increase food security by retaining trees on agricultural land, by encouraging natural regeneration and by planting trees and other forest plants. For most of the year, herders in arid and semi-arid lands depend on trees as a source of fodder for their livestock. Forests, trees and agro forestry systems contribute to food security and nutrition in many ways, but such contributions are usually poorly reflected in national development and food security strategies. Coupled with poor coordination between sectors, the net result is that forests are mostly left out of policy decisions related to food security and nutrition (FAO, 2018). In a word a healthy ecosystem can give available food, Wood, Fiber, biofuels & plant oils. According to the respondents, they have a clear concept about oxygen circulation that if a healthy ecosystem is sustainable, then healthy oxygen will be available in nature. Now Climate change is the most discussing topics in everywhere. So people are also conscious about the climate & air quality. They consider this ecosystem services come from nature.

Carbon sequestration and storage is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming (Sedjo & Sohngen, 2012). Respondents are also slight conscious about this topic. They know how carbon can sequestrate and storage. They emphasis on more production of herbs, shrubs, trees, medicinal resources and agricultural products in homestead forest, agricultural land and fully conserve natural ecosystem. If the watershed and nature will conserve that means plant species properly managed fresh water will be increased. By appropriate management of sustainable ecosystem, ecotourism will be developed which facilitate aesthetic, recreational and tourism facilities. Respondents have no clear concept about pollination and spiritual aspects of ecosystem services. But those are so essential services which can't explain simply. Without pollination nature can't expect any floral diversity in any kinds of ecosystem. Many species have spiritual aspects such as *Ficus bengalensis* (Bot) and*Ficus religiosa* (Asbatta) trees which are the worship matter for some religious people. Respondents are not so knowledgeable about disease and flood regulation. They are not conscious about educational aspects of ecosystem services. Finally to understand all kinds of ecosystem services, people should have a clear concept about those and manage their surroundings ecosystem in a proper way and should achieve sustainable ecosystem as well as development.

3.7.4 Perception about forest

According to the survey most of the respondent (80.67%) opined thathomestead forest at Household is increasing, decreased (12.61%) and no change (6.72%). Then homestead forest in the area increased (76.47%), decreased (18.07%) and no change (5.46%). Availability of NTFPs is increased (7.14%), decreased (31.93%) and no change (60.92%). Health of nearest forest is increased (41.60%), decreased (52.52%) and no change (5.88%). Wildlife is increased (14.71%), decreased (81.51%) and no change (3.78%) (Figure 9). In both aspects of household and the entire area, homestead forest is increased owing to people's awareness and less dependency on forest. Though maximum people observed no change of NTFPs,but NTFPs are also decreased because people are not so interested in growing NTFPs to collect raw material for ever decreasing cottage industries. Maximum respondents opined that healths of nearest forest are deteriorating than before in consequence of illicit felling and occupy woodland. As a result wildlife is also decreasing gradually.

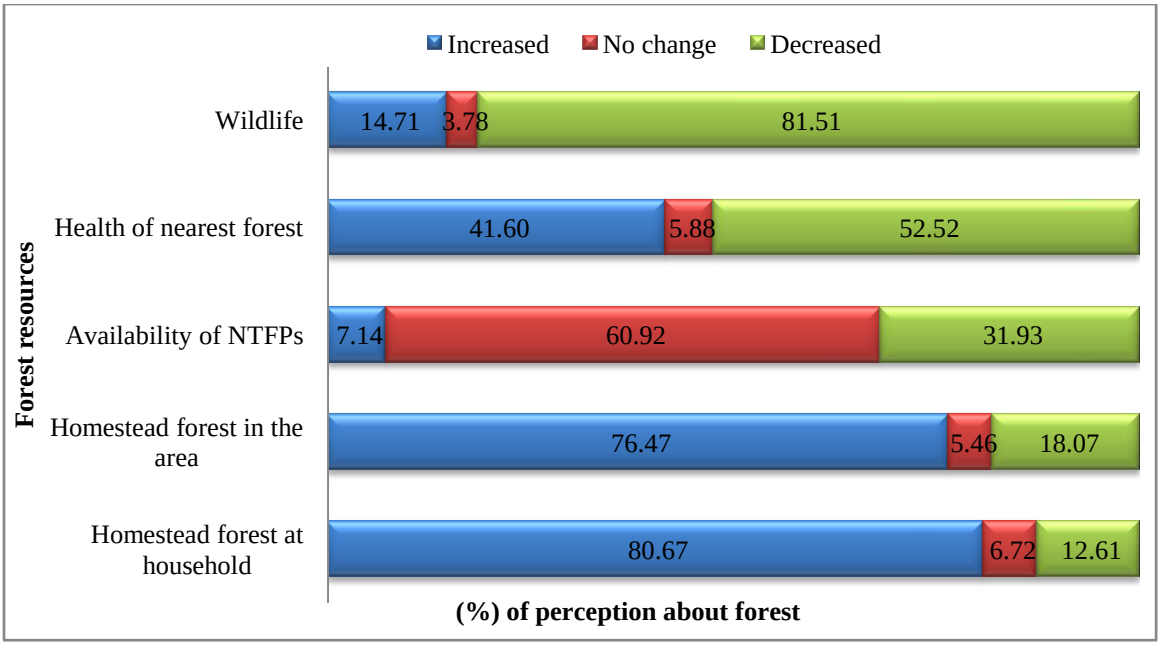

Figure 9: Perception about forest

3.8 Factors influencing people's perception on status of homestead forest

Table 12: Factors influencing people's perception on status of homestead forest in Hathazari Upazila

	Estimate	Odds Ratio	Std. Error	z Value	
(Intercept)	0.6603	1.9354	1.5790	0.4180	
EDUCATION	0.0924	1.0968	0.0496	1.8630	*
AREA_TYPE	-2.0550	0.1281	0.7172	-2.8650	***
HOSPITAL	-1.3170	0.2679	0.4888	-2.6960	***
FUELWOOD	0.5792	1.7846	0.4222	1.3720	
BELIEF	-1.3050	0.2712	0.5496	-2.3740	**

Note: ***Significant at 1 % level, **Significant at 5% level and *Significant at 10% level; Dependent Variable= Status of homestead forest in Hathazari Upazila (1if homestead forest increasing, 0 otherwise); EDUCATION= Number of schooling years of the respondent; AREA_TYPE= Location of the household (1=Semi-urban, 0=Rural); HOSPITAL= Whether hospital available at 3km radios (1=Yes, 0=Otherwise); FUELWOOD= Collect fuel wood from nearby forest (1=Yes, 0=Otherwise), BELIEF= Cultural belief related to forest (1=Yes, 0=Otherwise).

Table 12 represents how different factors influencing the perception on homestead forest in Hathazari Upazila. Of the five factors under consideration, EDUCATION, AREA_TYPE, HOSPITAL and BELIEF were found significantly influencing people's perception. The parameter estimates for EDUCATION was 0.0924 which was significant at 10% level. The associated odds ratio denotes that the log odds of homestead forest increasing versus not increasing are1.0968. Thus, it can be concluded that, people with one year more schooling year are more conscious than a respondent having one less schooling year about the condition of homestead forest in the area and concluding that the homestead forest is increasing. Unlike, EDUCATION, AREA_TYPE was found inversely significant at 1% level. Related odds ratio 0.1281 indicates a respondent in semi-urban area than his rural counterpart is stating homestead forest is decreasing in homesteads. This might be forest in semi-urban areas are decreasing. Similarly, HOSPITAL availability and cultural BELIEF were found significant at 1% and 5% level. Associated log odds were 0.2679 and 0.2712.

4. Conclusion

The result revealed that the complex ecosystem of Hathazari Upazila provides a wide range of goods and services which may be categorized as provisioning, regulating and cultural services. Available provisioning services include production of different forest products like timber, fuelwood, pole, bamboo, leaves, ornamental, medicinal, horticultural products etc., production of agricultural crops, livestock's which facilitated the native people with diversified livelihood source. People's dependency & activities in homestead forest are very prominent which also help to maintain the sustainability of the ecosystem through lessening illicit felling, encroachment & aggressive exploitation of natural resources. Moreover, the ecosystem also supplies a considerable amount of fresh water for aquaculture though various watersheds, food, wood, fiber, NTFPs and provides a favorable habitat for diversified fauna. On the other hand, efficient ecosystem function helps to ameliorate the environmental condition by controlling its different components e.g. soil, air, nutrient cycling and water and solid waste management. Vast vegetated area sequestered considerable amount of greenhouse gases & helps to regulate the pollution as well as provided a bulk amount of natural growing stock. Various climatic factors like temperature, humidity

and precipitation are also regulated effectively by the effective functioning of biotic & abiotic ecosystem. Furthermore, elevated geographic position & hilly area possess the capacity to moderate extreme weather events help to reduce the occurrence & adverse effects of several natural disasters e.g. flood, cyclone and disease. Prolific socio-economic & demographic characteristics of the study area also reflect the efficiency, enhanced productivity & sustainability of the entire ecosystem. Diversified landscape of the ecosystem also provides different types of cultural and habitat services like recreation, ecotourism, spiritual, aesthetic values along with good education, research and residential facilities which are directly or indirectly support to human wellbeing. However, if all other uncovered areas are taken under organized plantation program the functioning of the ecosystem will be good and it will serve its services more proficiently.

The study recommends an integrated management approach for Hathazari Upazila considering all types of ecosytem services for proper functioning of the sustainable ecosystem. If modern facilities and well management plans are applied & the existing problems are minimized; the conservational status of the bio-diversity will be improved and it will be the most attractive place for the tourists as well.

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List of Acronyms

AGB	=	Above Ground Biomass
AOI	=	Area of Interest
BCEF	=	Biomass Carbon Expansion Factor
CU	=	Chittagong University
ESS	=	Ecosystem Services
FAO	=	Food and Agricultural Organization
GLM	=	Generalized Linear Model
HHs	=	Households
HU	=	Hathazari Upazila
GFRA	=	Global Forest Resource Assessment
GIS	=	Geographic Information System
GLM	=	Generalized Linear Model
GPS	=	Global Positioning System
IFESCU	=	Institute of Forestry & Environmental Sciences, University of Chittagong
IVI	=	Importance Value Index
LPG	=	Liquefied Petroleum Gas
MEA	=	Millennium Ecosystem Assessment
RA	=	Relative Abundance
RD	=	Relative Density
RD_o	=	Relative Dominance
RF	=	Relative Frequency
RS	=	Remote Sensing
SBGE	=	Sitakunda Botanical Garden and Eco-park
TEEB	=	The Economics of Ecosystem and Biodiversity
USGS	=	United States Geological Survey

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